STS-97 IFA CABLE INVESTIGATION

Presenter:
Robert Wright
Organization/Date:
USA-SRB/1-15-01

Current Status (cont.)

- Additional screens implemented on STS-98 mission
  - X-ray ETAR WTR ordnance cables on both SRBs
  - Electrically test ETAR WTR ordnance cables on both SRBs
  - Cable matrix assembled to evaluate other SRB cables
    - Evaluation performed using type of cable, criticality, lifecycle processing and handling, and historical nonconformance data
    - Identified Forward Separation Bolt Ordnance cables with prior non-conformance history of shield damage
      - Added these cables to x-ray inspection
  - Based on x-ray results, two cables removed and replaced
  - Electrical tests identified damaged shield on LH ETAR WTR ordnance cable, lower strut system "B"
    - Cable re-terminated with new connector
    - Repaired cable successfully passed electrical tests

STS-97 IFA CABLE INVESTIGATION

Presenter:
Robert Wright
Organization/Date:
USA-SRB/1-15-01

Current Status (cont.)

- Previously flown RSRM ignition cables verified acceptable by inspection or test
- Cable sampling plan developed to gain additional insight into condition of all types of SRB cables
  - Engineering assessment selected 100 cables in 13 families based on construction/configuration
  - X-rayed all 100 cables selected
  - No similarities to STS-97 IFA cable found during inspection

SRB CABLE INVESTIGATION

Presenter: Robert Wright

Organization/Date: USA-SRB/1-15-01

Problem

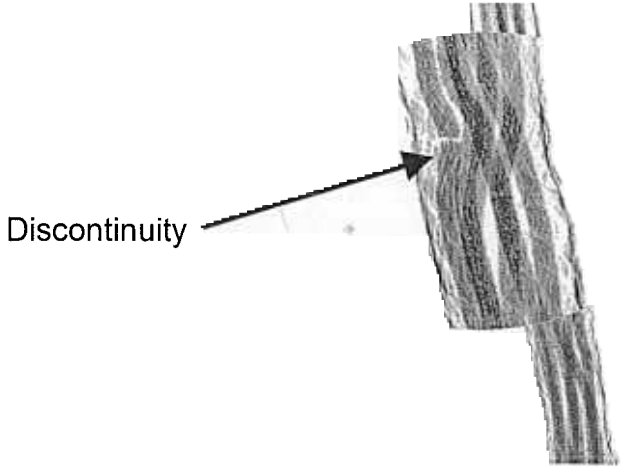
- During x-ray inspection of 100 cable sample for STS-97 IFA investigation a break was identified in one conductor of Forward tunnel cable, S/N 1000018
  - Cable provides "C" bus power to forward IEA
  - 6 conductor watertight reusable cable
    - One twisted pair of spare wires
    - One twisted quad for supply and return, redundant
  - Break verified in continuity test while flexing cable

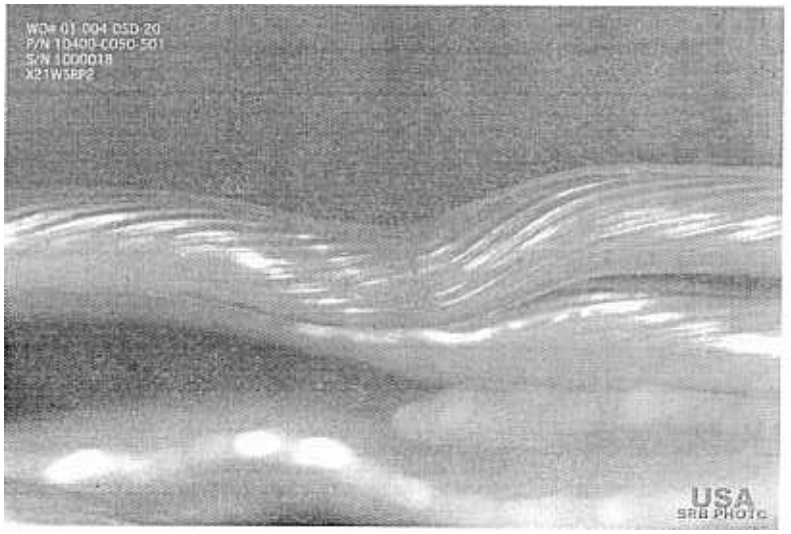
SRB CABLE INVESTIGATION

Presenter:
Robert Wright
Organization/Date:
USA-SRB/1-15-01

Problem (cont.)

- Failure analysis showed
  - No shield damage
  - Break occurred at a "kink" in spare wire at the connector mold to polyurethane jacket transition





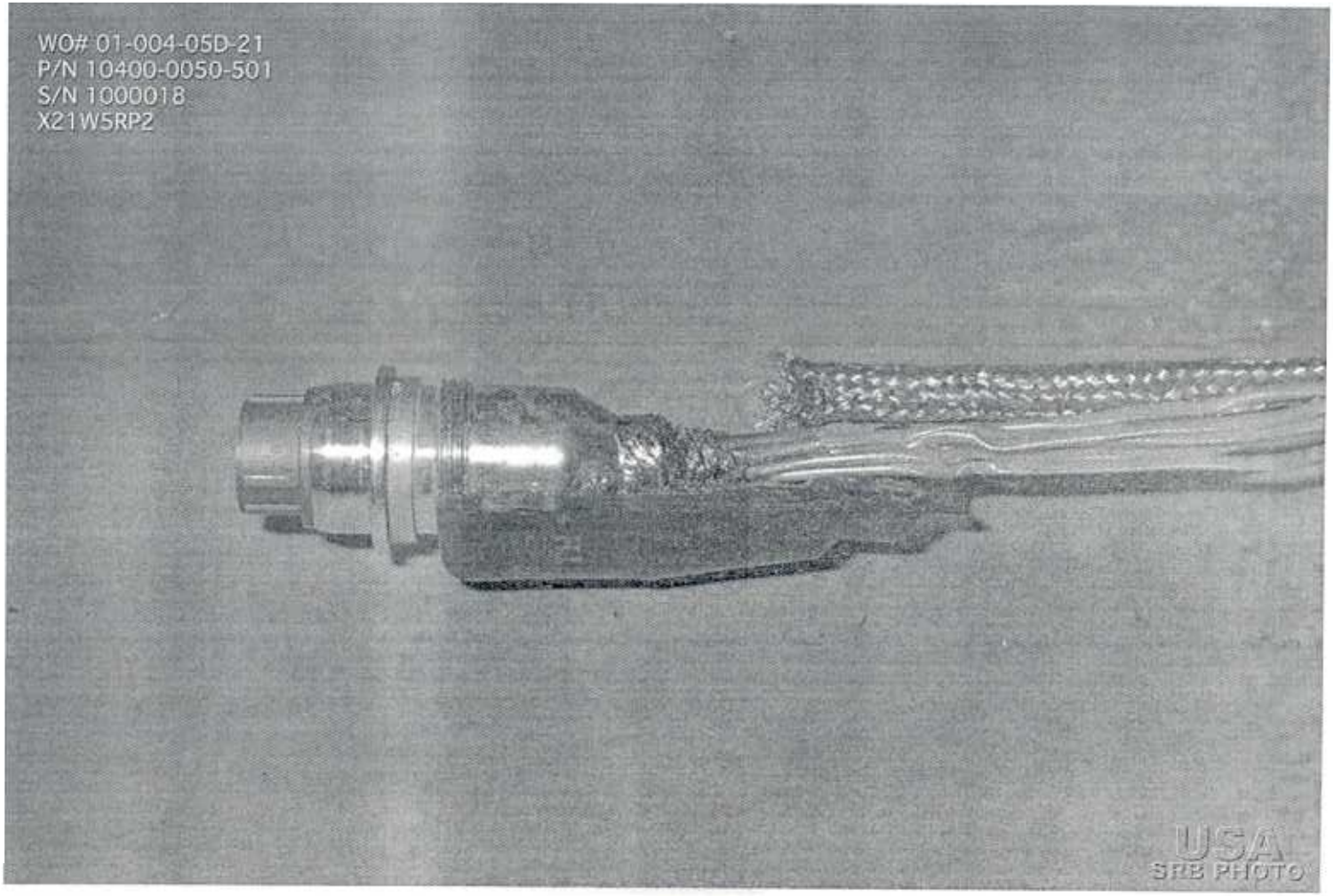
Forward Tunnel Cable

(showing wire break magnified)

SRB CABLE INVESTIGATION

Presenter:
Robert Wright

Organization/Date:
USA-SRB/1-15-01



STS-98

United Space Alliance

SRB CABLE INVESTIGATION

Presenter: Robert Wright

Organization/Date: USA-SRB/1-15-01

Current Status (cont.)

- No broken strands found in other five conductors
- No chemical or thermal damage noted
- Microscopic evidence indicated this was not a recent failure, fracture surfaces exhibited wear

- Based on failure found on 1000018 cable, team requested additional testing of WTR cables
  - Statistically significant sample size calculated based on population of 700 WTR cables
  - Selected additional 123 cables from inventory
    - 23 were additional databus cable assemblies
  - Team requested wiggle test and x-ray of STS-102 system tunnel cables
    - 36 of 38 cables available for inspection
- Electrical bench flex test developed to evaluate conductor continuity of cables in SRB inventory

SRB CABLE INVESTIGATION

Presenter: Robert Wright

Organization/Date: USA-SRB/1-15-01

Current Status (cont.)

- Cable sample summary
  - 223 cables x-rayed and bench flex tested
  - 36 cables x-rayed and wiggle tested (on vehicle STS-102)
  - 259 total cables tested
  - 183 of 223 are WTR
  - 194 of 259 are systems tunnel WTR

SRB CABLE INVESTIGATION

Presenter: Robert Wright

Organization/Date: USA-SRB/1-15-01

Current Status (cont.)

- X-ray inspection:
  - One broken conductor found (1000018)
  - Minor to moderate shield damage found on some cables - nothing similar to STS-97 IFA cable
- Bench flex test:
  - Three cables found with a broken conductor
- All four cables were system tunnel WTR cables
- Three of four failures were at aft IEA interface
- Three of four failures were in spare wires (not tested after installation)

SRB CABLE INVESTIGATION

Presenter:
Robert Wright
Organization/Date:
USA-SRB/1-15-01

Systems Tunnel WTR Cables Test Summary

	# cables	# connectors	# conductors	# conductor locations
Inventory (14 Flight sets)	532	1064	9240	18480
Bench Testing				
1st "100" cables	35	70	2372	4744
"123" cables	123	246		
Totals	158	316		
On Vehicle Testing				
STS-102	36	72	656	1312
Total tested	194	388	3028	6056
(% of inventory)	(36%)	(36%)	(33%)	(33%)
Total failed	4	4	4	4
(% of tested)	(2.06%)	(1.03%)	(0.132%)	(0.066%)
% passed	97.94%	98.97%	99.868%	99.934%

STS-98

United Space Alliance

SRB CABLE INVESTIGATION

Presenter:
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Statistical Risk Assessment

- Assumptions
  - Conductor wire failures caused by random events
  - Higher number of missions results in higher chance of finding conductor failure
    - Due to number of exposures to random event, not cycle fatigue
  - No process shift or common cause
- Analytical approach
  - Calculated using data at conductor level from 194 system tunnel cables
    - 3028 conductors, at two locations each
  - Four failures found
- Reliability calculations
  - Conductor demonstrated reliability calculated using conductor data
  - Use conductor demonstrated reliability to calculate system (vehicle) reliability

SRB CABLE INVESTIGATION

Presenter: Robert Wright

Organization/Date: USA-SRB/1-15-01

Statistical Risk Assessment (cont.)

- Account for series (supply & return) and parallel (redundant) arrangement
- Reliability Results
  - Based on four failures found: Flight risk is less than 1 in 7,200
    - Equivalent to a reliability of 0.99986

STS-98 FLIGHT RATIONALE

Presenter:
Robert Wright
Organization/Date:
USA-SRB/1-15-01

STS-98 ETAR WTR Ordnance Cable Rationale for Flight

- Cable experience shows shield damage occurs prior to damage of conductors
- X-rays of all ETAR WTR ordnance cables show no evidence of damage similar to STS-97 IFA
  - Cables with suspect shield damage were repaired or replaced
- All ETAR WTR ordnance successfully passed electrical tests cables after final installation
- No evidence of gross handling damage observed in any inspections initiated by STS-97 IFA
- All critical measurements and functions are redundant by design

STS-98 FLIGHT RATIONALE

Presenter:
Robert Wright
Organization/Date:
USA-SRB/1-15-01

STS-98 System Tunnel Cables Rationale for Flight

- Demonstrated reliability shows zero in-flight failures during 101 missions
  - Statistical risk assessment shows demonstrated reliability of 0.99986
- All critical measurements and functions are redundant by design
  - In addition, power circuits have redundancy within each cable
- All other cables, non-WTR, evaluated through testing and non-conformance history, were found acceptable

Team recommendations are mixed regarding flight readiness